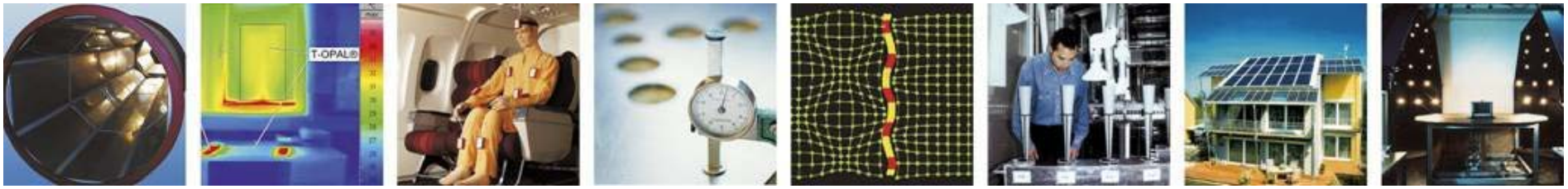


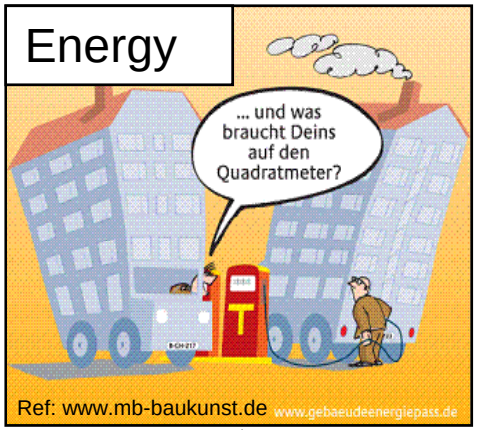
Development of an object-oriented building physics library and investigation and optimization of hygrothermal and hygienic comfort in rooms

Thierry Stephane Nouidui
Simulation Research Group
Building Technologies Department
Environmental Energy Technologies
Lawrence Berkeley National Laboratory

Motivation

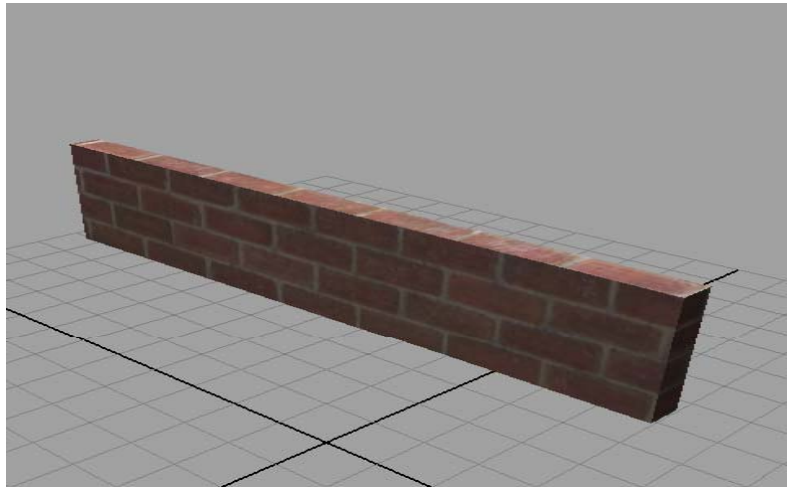

Mold growth
Ref: Sedlbauer


Comfort
Ref: www.cool-equip.co.uk


Energy
... und was braucht Deins auf den Quadratmeter?
Ref: www.mb-baukunst.de
www.gebaeudeenergiepass.de

Motivation

WALL MODEL



BUILDING MODEL

Equation-Based Object-Oriented Hygrothermal Building Physics Library (MODELICA)

Overview

- Motivation
- **Objectives**
- Equation-Based Object-Oriented Building Physics Library
- Validation of the Building Physics Library
- Application
- Summary and Outlook

Approach

Modelling

Validation

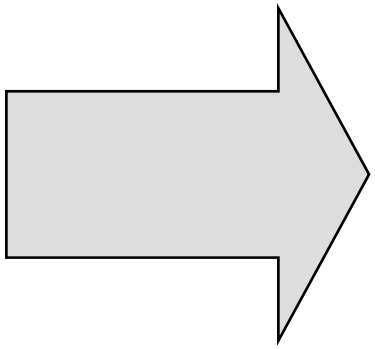
Optimization

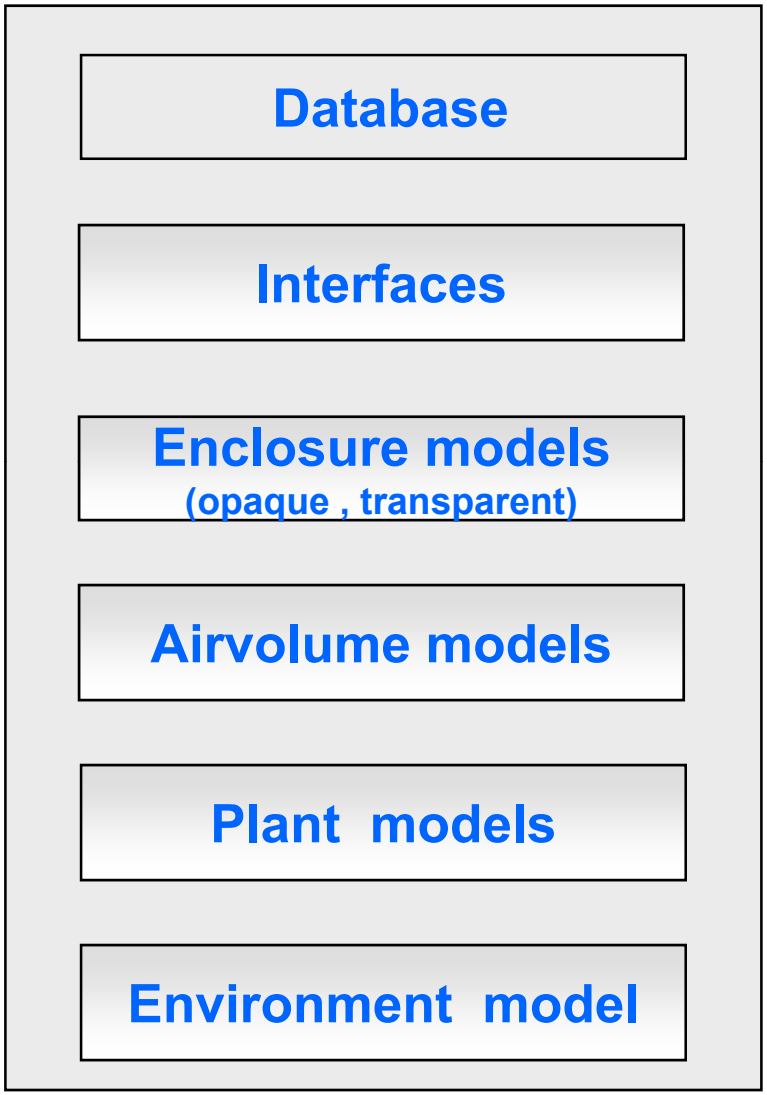
Overview

- Motivation
- Objectives
- **Equation-Based Object-Oriented Building Physics Library**
- Validation of the Building Physics Library
- Application
- Summary and Outlook

Equation-Based Object-Oriented Building Physics Library

Behaviour of a real building





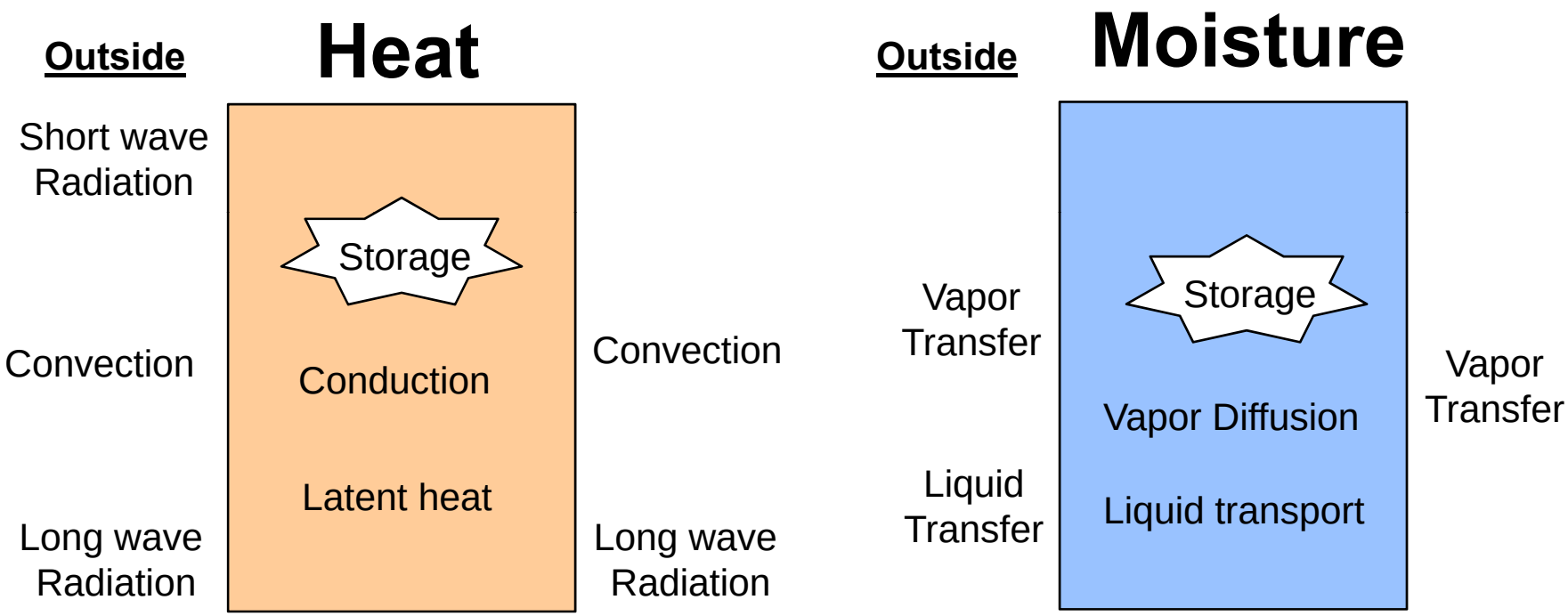
Overview

- Motivation
- Objectives
- Equation-Based Object-oriented Building Physics Library
- **Validation of the Building Physics Library**
- Application
- Summary and Outlook

Validation of the Building Physics Library

1D – Wall model

Physical model/ Heat-Moisture



Validation of the Building Physics Library

Validation of the 1D - Wall model

1. **Analytical solution**
   - Heat transfer
   - Diffusion
2. **WUFI (Waerme Und Feuchte Instationaer)**
3. **HAMSTAD**
   - Benchmark 1
   - Benchmark 3

Validation of the Building Physics Library

Validation of the 1D - Wall model

1. Analytical Solution

2. WUFI (Waerme Und Feuchte Instationaer)

3. **HAMSTAD**

Objectives

HAMSTAD work was undertaken as part of EU-initiated project
for standardization of HAM (Heat-Air-Moisture) calculation methods.

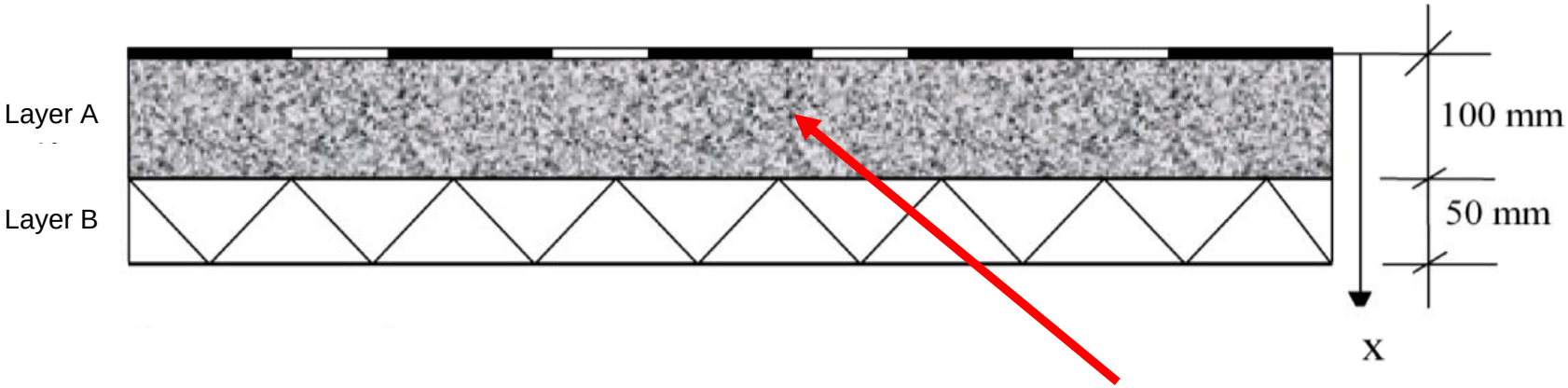
It was suggested that the benchmarks be used as references in the assessment of existing and new software packages

Validation of the Building Physics Library

Validation of the 1D - Wall model

3. HAMSTAD

- **Benchmark 1**



Boundary Conditions:

Climate: transient

Simulation time: 1 year

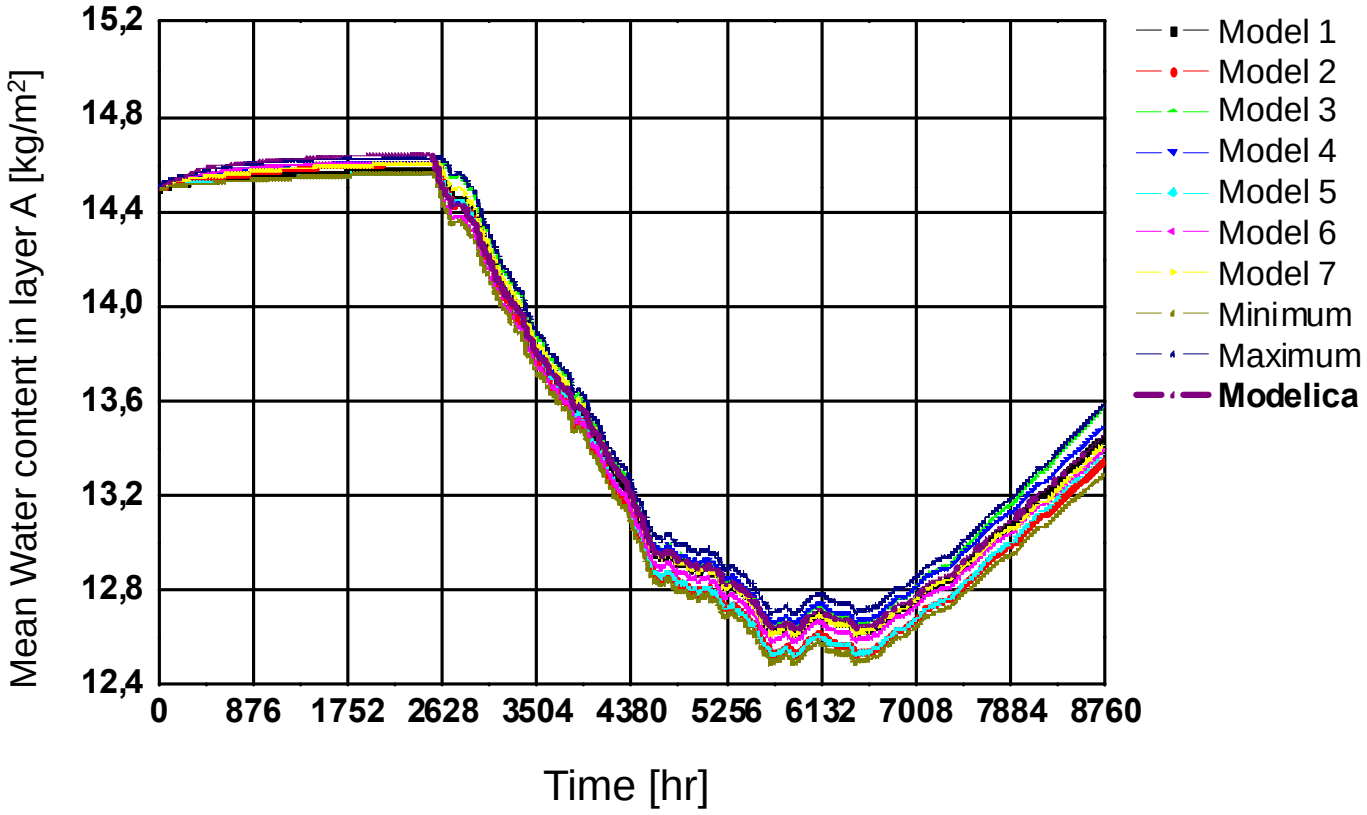
Simulation result: Mean water content in layer A

Validation of the Building Physics Library

Validation of the 1D - Wall model

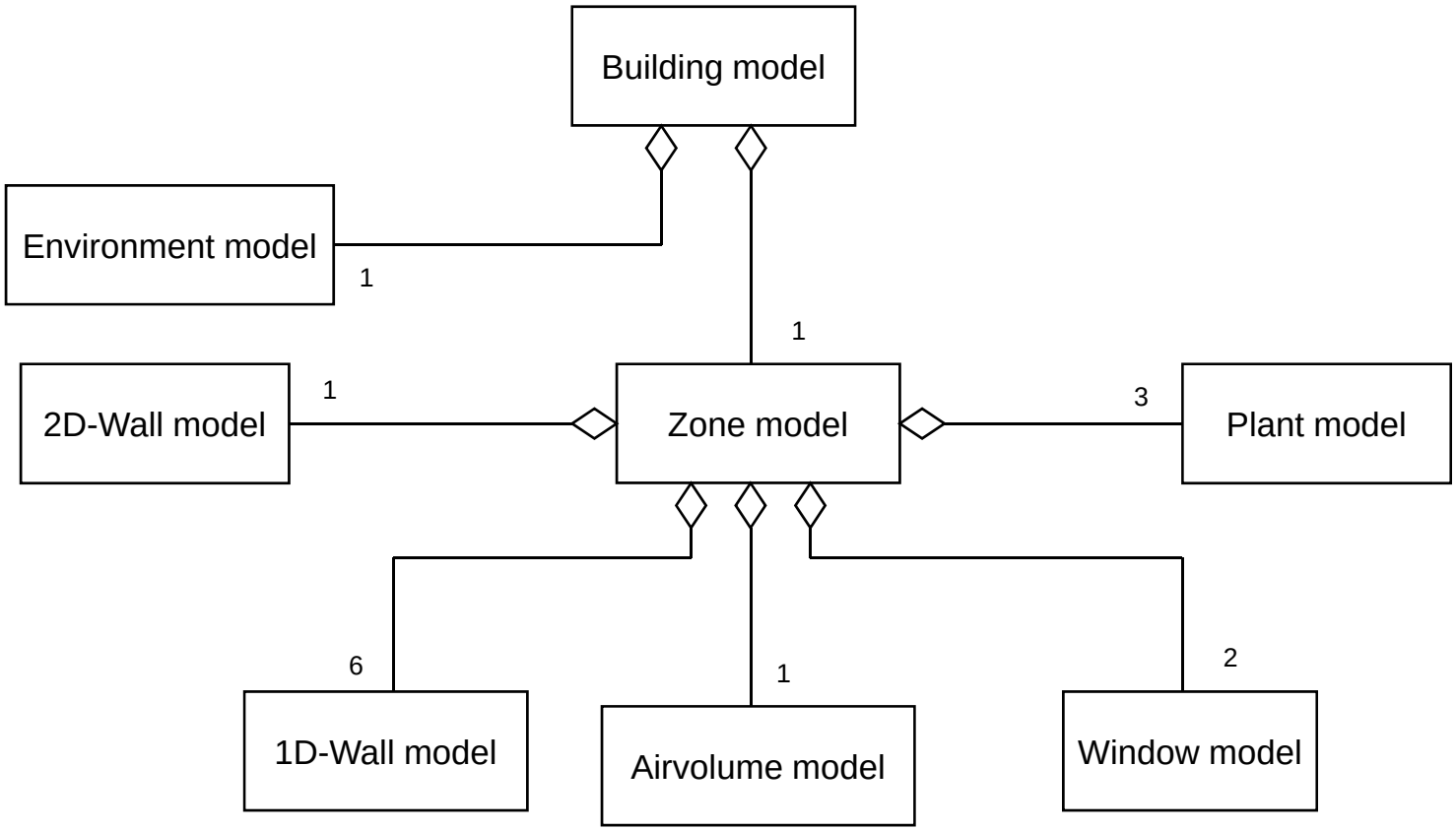
3. HAMSTAD

- **Benchmark 1 / Simulation results**



Validation of the Building Physics Library

Validation of the room model



Validation of the Building Physics Library

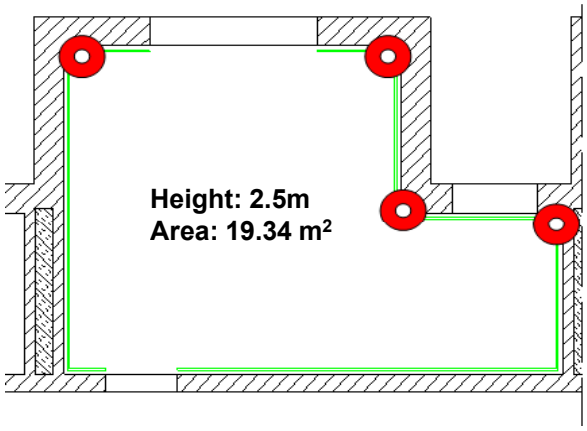
Validation of the room model

1. **Residential Building**
    - **Reaction to the outside climate (Free floating room)**
    - **Reaction to a moisture source**
2. **Office Building**

Validation of the Building Physics Library

Validation of the room model

Free floating Room



Boundary conditions:

- n = 0.65 h^{-1}
- No solar radiation
- No heat sources
- Period: 15. - 25.11.2006

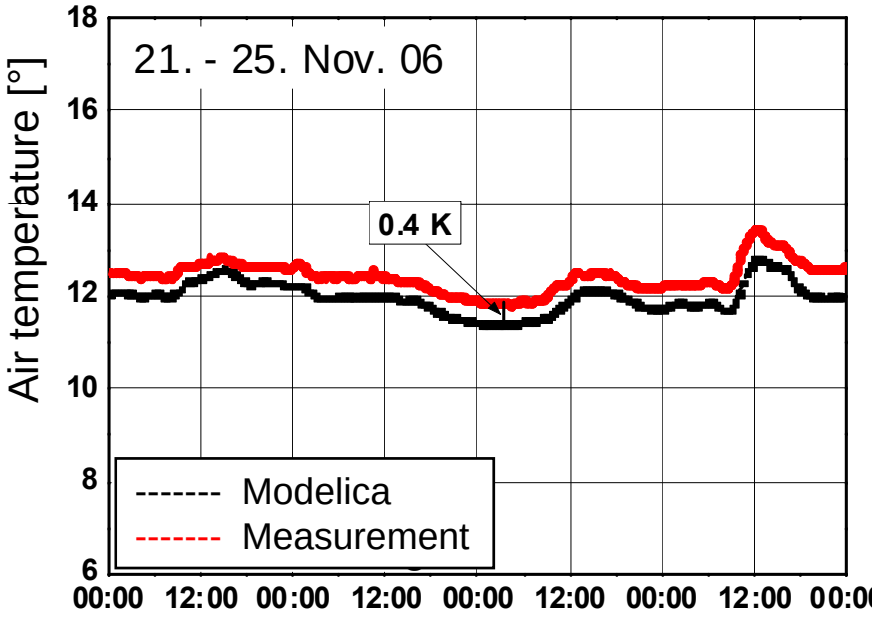
Results:

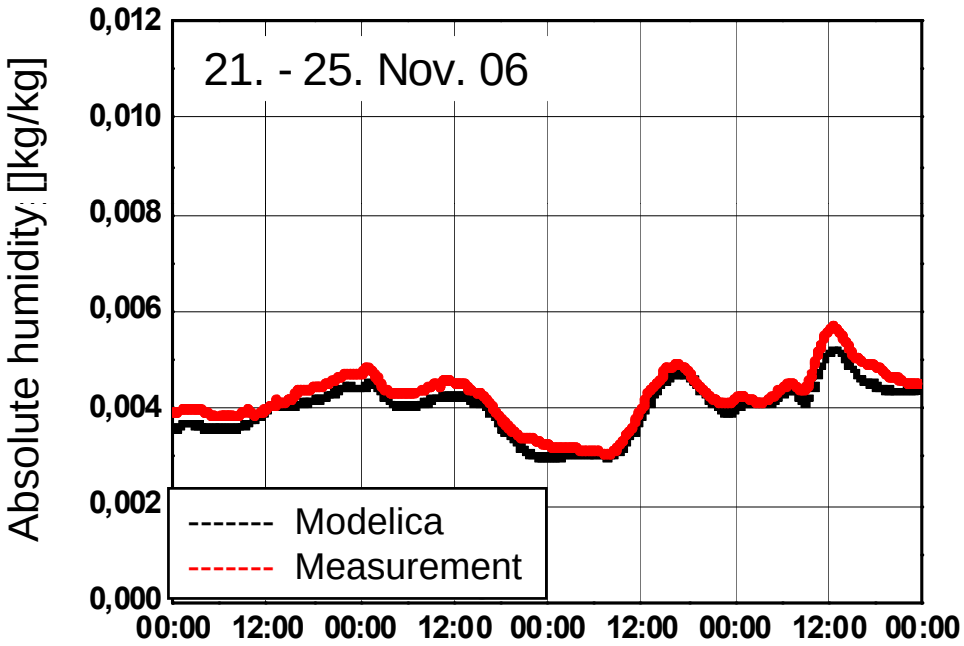
- Air temperature in the middle of the room
- Air humidity in the middle of the room

Validation of the Building Physics Library

Validation of the room model

Free floating Room





Overview

- Motivation
- Objectives
- Equation-Based Object-oriented Building Physics Library
- Validation of the Building Physics Library
- **Application**
- Summary and Outlook

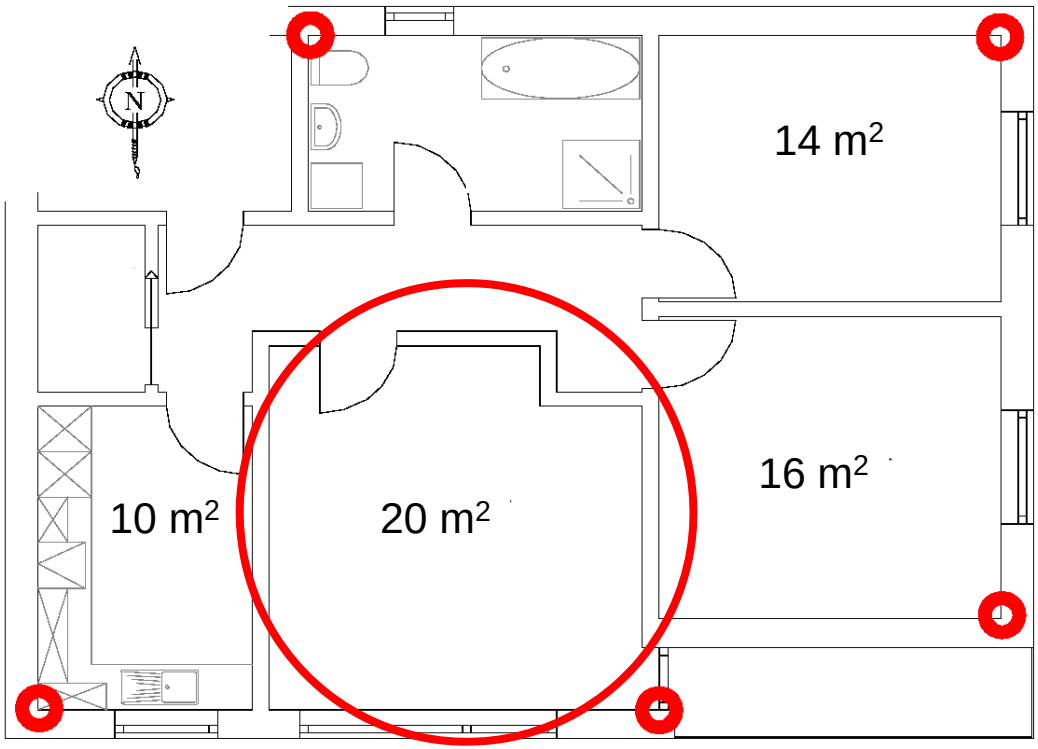
Application

Residential room

1. **Consequences of Building Retrofit:**
    - Hygienic comfort (Mold growth, air quality)
    - Hygrothermal comfort (comfort)
2. **Ventilation strategies**
    - Cross ventilation
    - Constant ventilation
    - Controlled ventilation

Application

Residential room



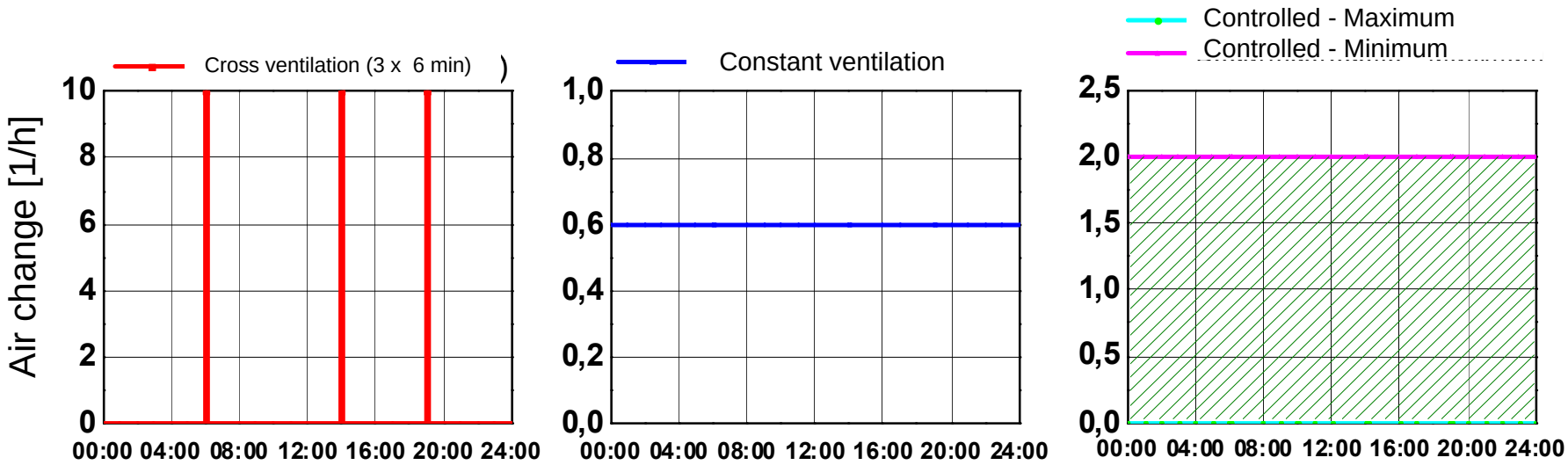
Different configurations

- **Config. 1:** old building with leaky windows (n = 0.7 h^{-1}, U_w = 1.5 W/m^2K, U_f = 2.6 W/m^2K)
- **Config. 2:** old building with tight windows (n = 0.1 h^{-1}, U_w = 1.5 W/m^2K, U_f = 1.1 W/m^2K)
- **Config. 3:** insulated old building with tight windows (n = 0.1 h^{-1}, U_w = 0.4 W/m^2K, U_f = 1.1 W/m^2K)

Application

Residential room

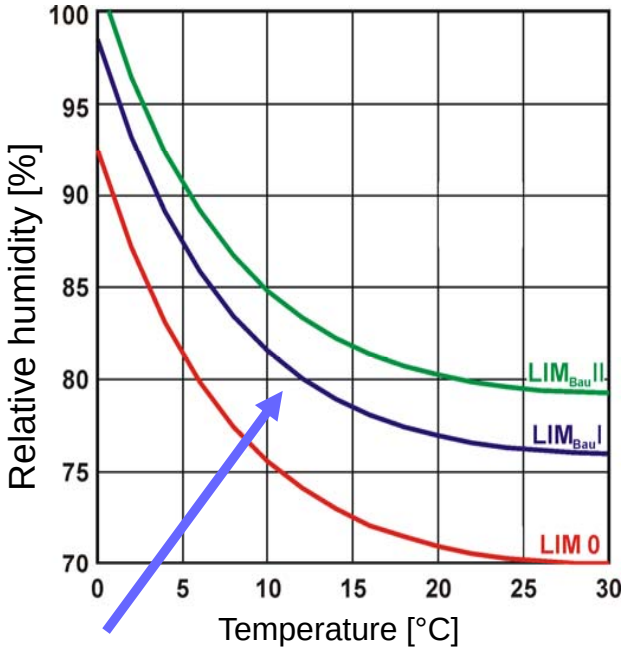
- Cross ventilation
- Constant ventilation
- Controlled ventilation



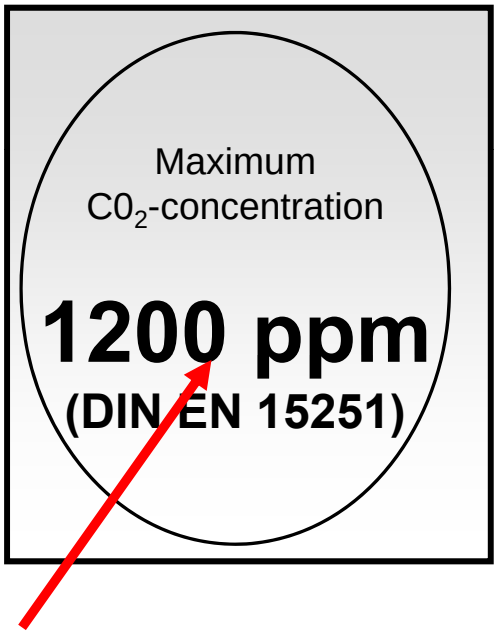
Application

Residential room (criteria)

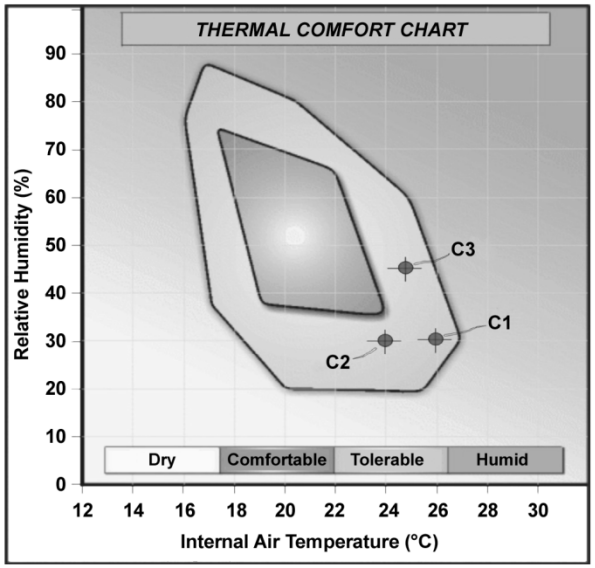
Mold growth



Air quality

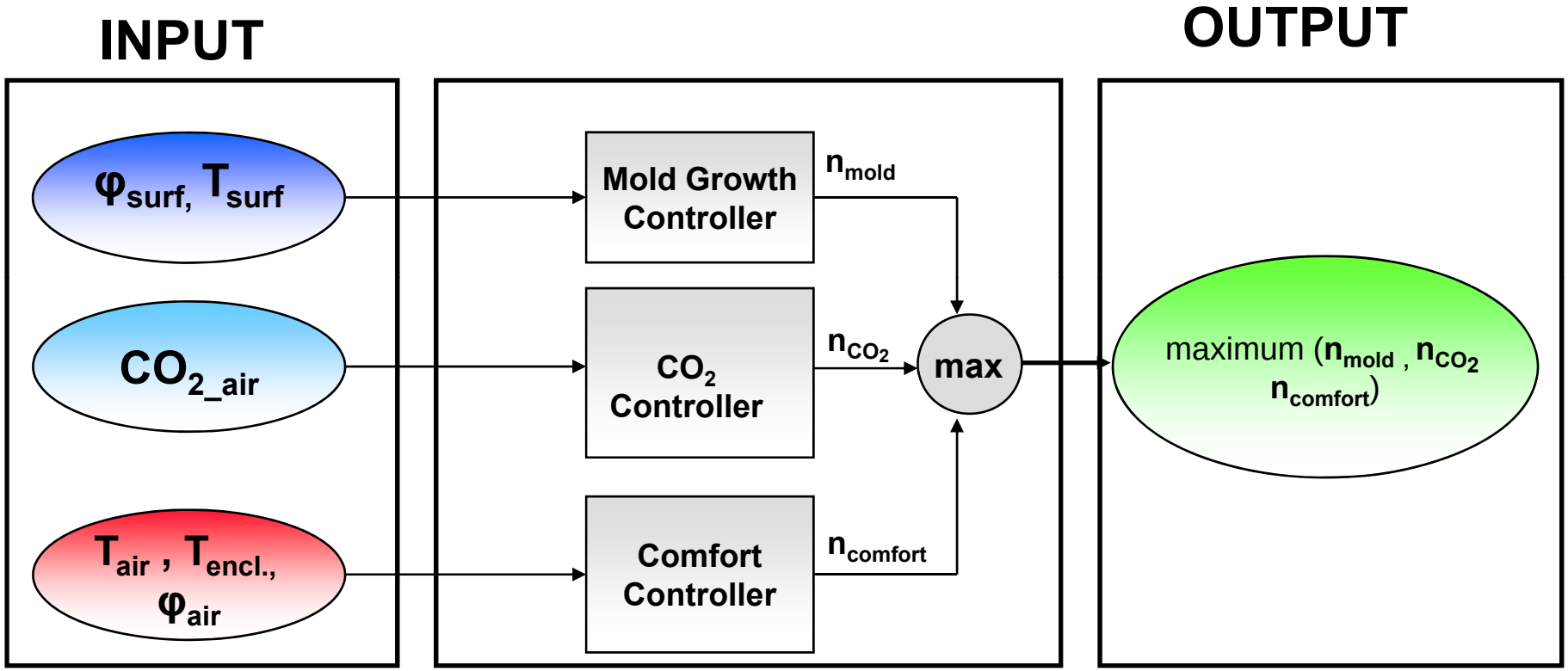


Comfort



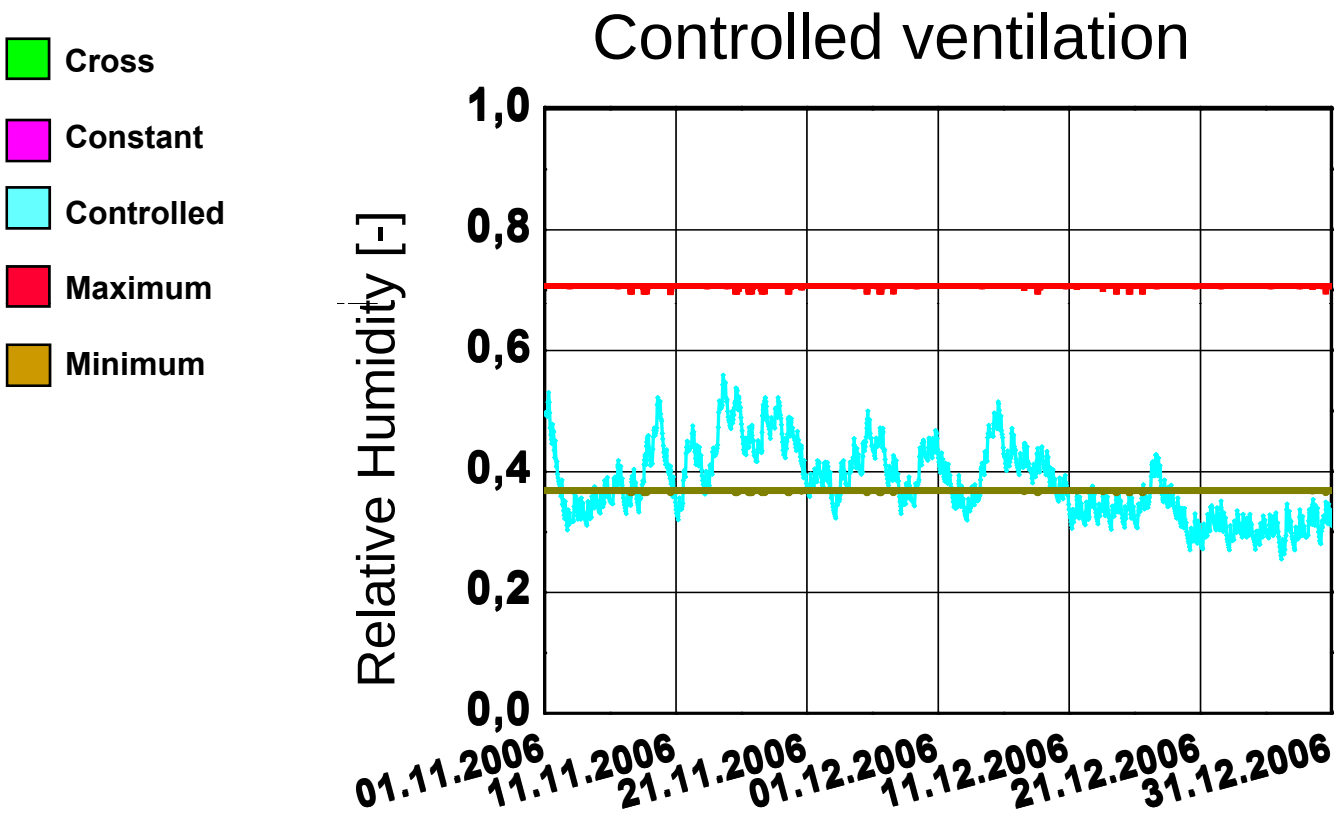
Application

Residential room (controlled ventilation system)



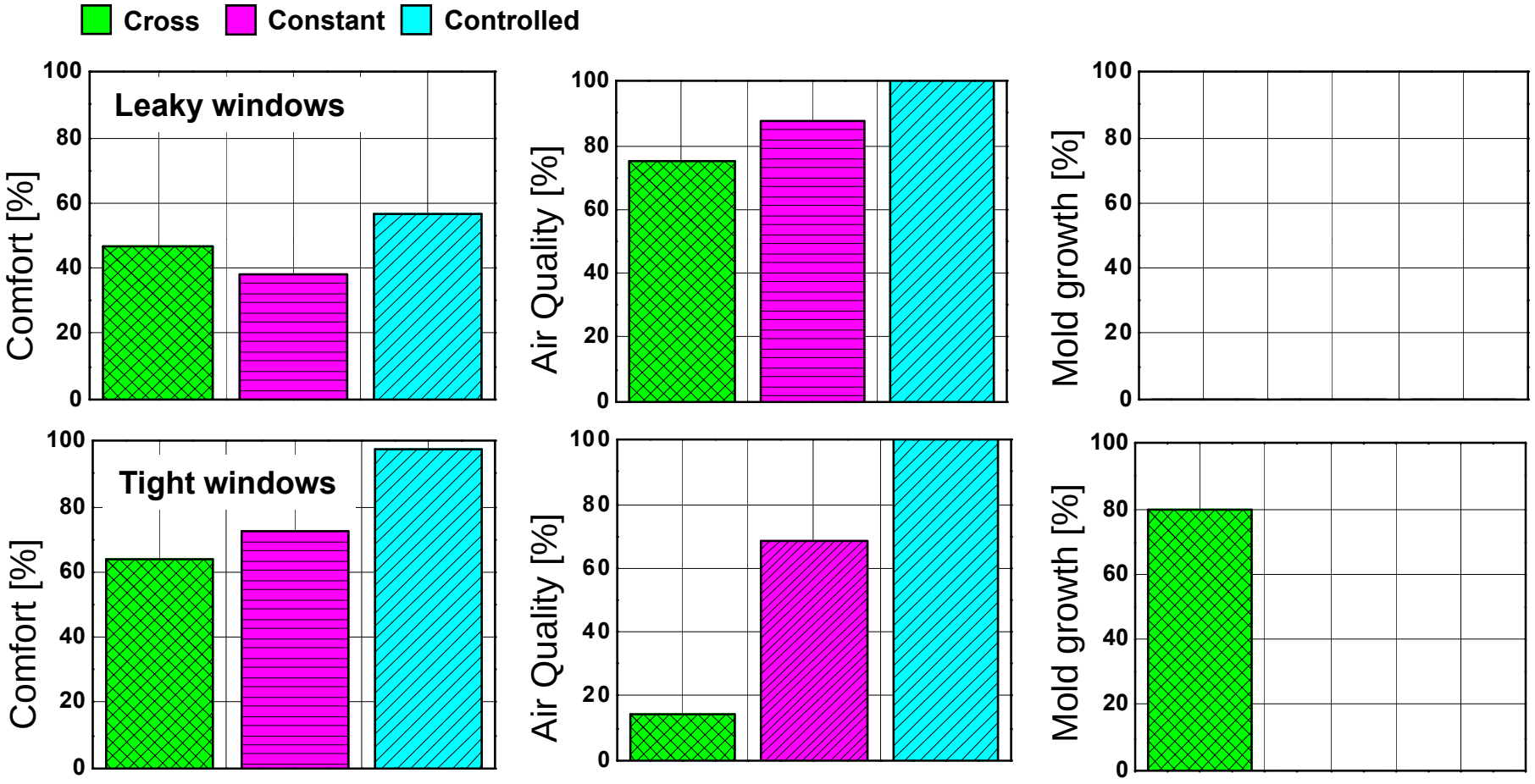
Application

Simulation results: Config.1: Old building with leaky windows – Comfort



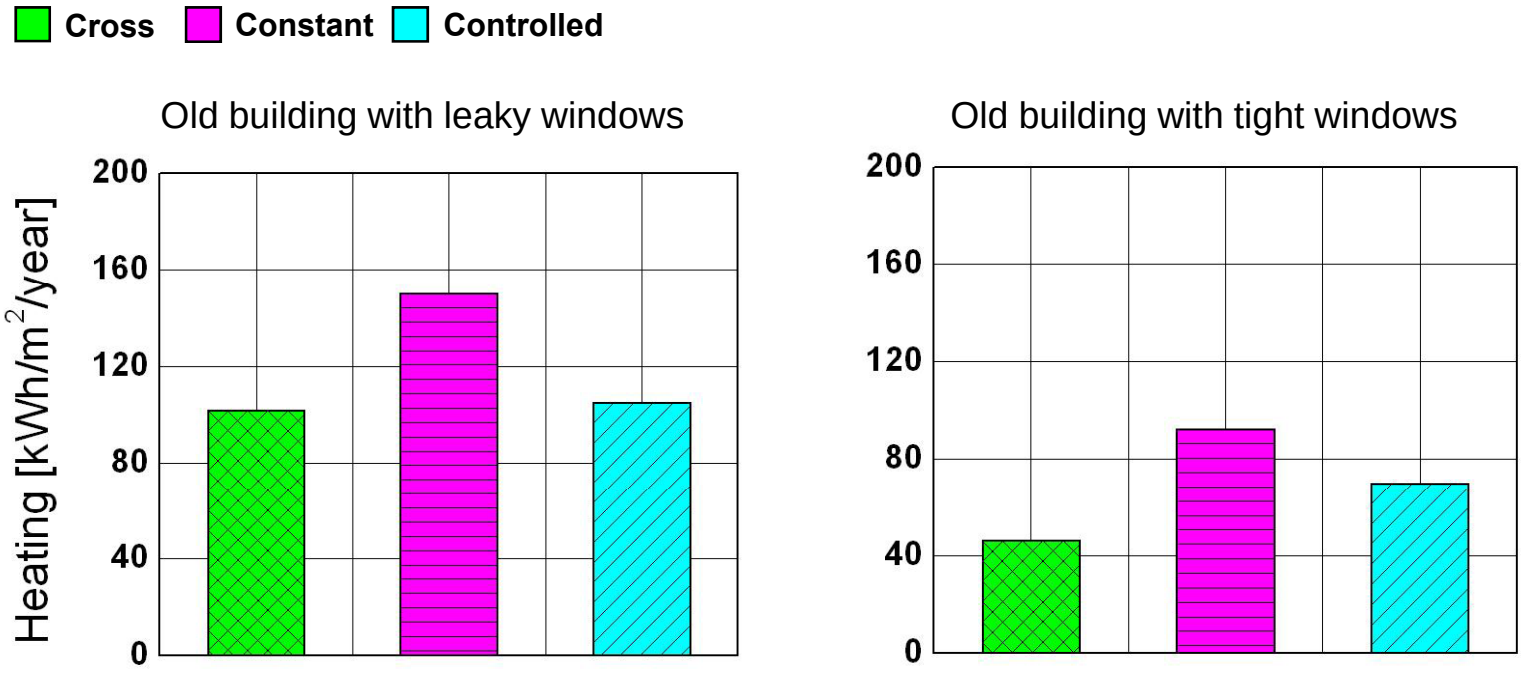
Application

Simulation results: Config. 1: old building with leaky windows– Config. 2: old building with tight windows



Application

Simulation results: Config. 1: old building with leaky windows– Config. 2: old building with tight windows



Conclusions:

- Controlled ventilation system is optimal (after the retrofit)
- Cross ventilation could be an alternative but...

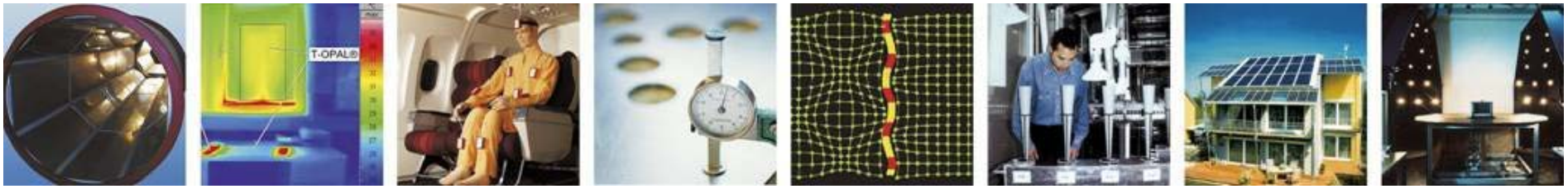
Summary and outlook

Summary

- Development of an Equation-Based Object-Oriented Building Physics Library
- Validation of the Building Physics Library
- Application: Analysis of the consequences of a ,,wrong‘‘ Building retrofit

Outlook

- Extend the Building Physics Library
- Simulator coupling (BCVTB)



Development of an object-oriented building physics library and investigation and optimization of hygrothermal and hygienic comfort in rooms

Thierry Stephane Nouidui
Simulation Research Group
Building Technologies Department
Environmental Energy Technologies
Lawrence Berkeley National Laboratory